RESEARCH DEPARTMENT

MODIFICATIONS TO THE BROOKMANS PARK HOME-SERVICE MAST-RADIATOR

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(W.Proctor Wilson)

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MODIFICATIONS TO THE BROOKMANS PARK HOME-SERVICE MAST-RADIATOR

Summary

The report describes modifications to the London Home-Service mast-radiator completed in September, 1952. Provision has been made for driving the mast simultaneously at the base and across the break previously used for series loading. New components have been installed in the A.T.H., both for base-feeding (standby circuit) and for double-feeding (main circuit). The distribution of current on the mast has been measured for both circuits. Measures have been taken to reduce re-radiation from nearby masts and aerials.

Preliminary records of fading have suggested that, in the case of the main circuit, a minimum of sky wave occurs at a range of about 135 km, as expected in theory. Further experiments are necessary to obtain fuller information on the vertical radiation pattern of the modified mast-radiator.

1. Introduction

Since September, 1946, a 507 ft. mast has been used at Brookmans Park to radiate the London Home-Service programme. The operating frequency was 877 kc/s before March, 1950, and has been 908 kc/s since that date. The maximum power permitted by the Copenhagen Plan is 140 kW, but the power delivered by the feeder to the Aerial Tuning House (A.T.H.) appears, from r.f. measurements, to be approximately 115 kW under present operating conditions.

The mast is about one half-wavelength in height, is provided with a capacity top, and is broken by an insulator about one-tenth of a wavelength from the top (Fig.1). Up to September, 1952, the mast was series-loaded, i.e. it was fed at the base, while a loading coil across the break was adjusted to give the required effective height.[1,2]

The vertical radiation pattern of a base-fed mast-radiator exhibits a minimum at an angle that depends upon the effective height, and the magnitude of the minimum field influences the degree of fading experienced near the fringe of the service area. The minimum field is not zero for two reasons. In the first place the distribution of current along the aerial is not cophased, owing to the presence of the feed current, which is associated with the flow of power from the feed point. In the second place the magnitude of the reflection coefficient at the surface of imperfectly conducting ground is less than unity. The first of these effects can be overcome by feeding a mast-radiator at a break near to the current loop (centre-feeding), instead of at the base.[3] The effect of finite ground conductivity can be overcome by feeding at the break and base simultaneously (double-feeding), in such a manner that more than the radiated power is supplied to the break, the excess being recovered at the base.[4,5] The Daventry Third-Programme Mast-Radiator[6] was designed for centre or double feeding, and it was decided by the Director of Technical Services, to modify the Brookmans Park Home-Service aerial for operation in a similar manner.

2. Mast and Aerial Tuning House

The principal dimensions of the mast are shown in Fig.1. It is of lattice construction, the cross-section being triangular with 6 ft. sides. A capacity top is provided by three radial arms and tie wires. Impedance measurements made previously[2], as well as experience of similar aerials, indicated a characteristic impedance of 250 Ω and a velocity factor of 0.9. The capacity top effectively extends the height by 45 ft.* to a total of about 550 ft.

The mast was modified by the addition of an unbalanced transmission line with a characteristic impedance of 100 Ω within the lower section of the mast. This consists of four inner conductors on a pitch circle of 6.25 in. diameter surrounded by eight outer conductors on a circle of 18 in. diameter. The conductors are 0.5 in. in diameter in each case. The outer conductors are bonded to the mast structure at intervals and the inner conductors are supported by insulators. At the break, the inner is connected to the upper section of the mast. The loading coil across the break (through which the mast-head lighting circuits are run) was retained, its inductance being set to its maximum value of 55 μH.

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* Estimated from impedance measurements, assuming a velocity factor of 0.9

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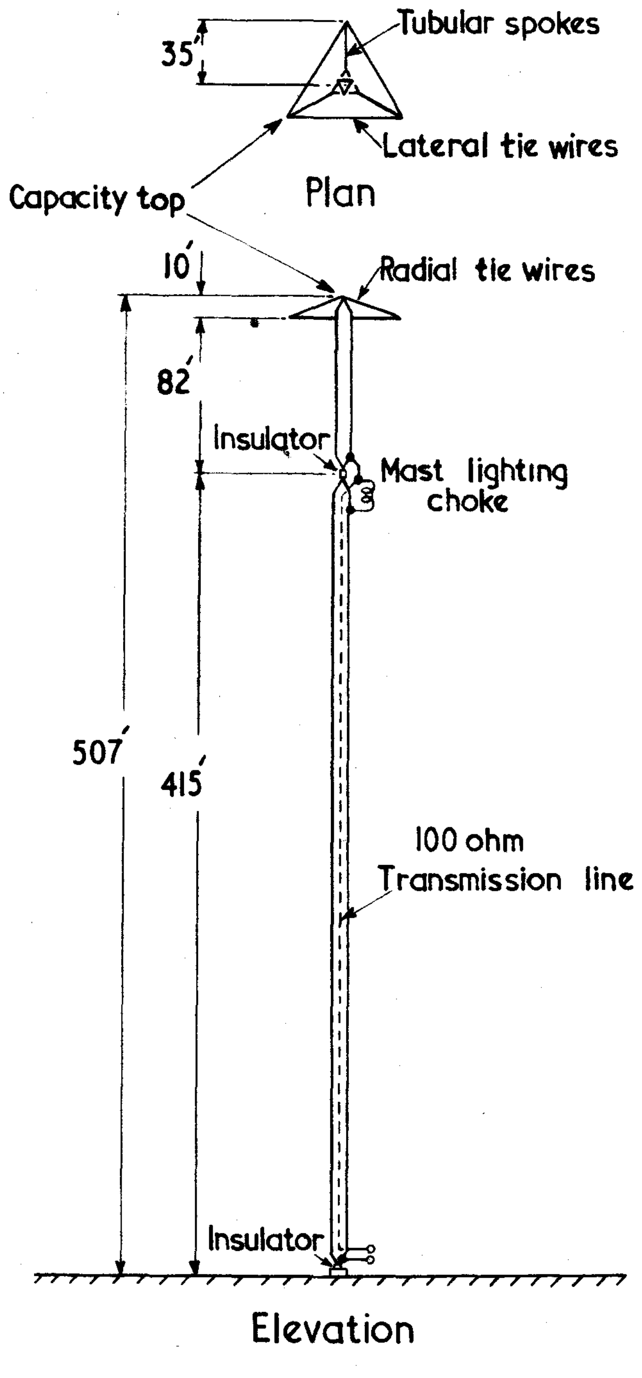

Fig. 1.

Dimensions of "F" mast.

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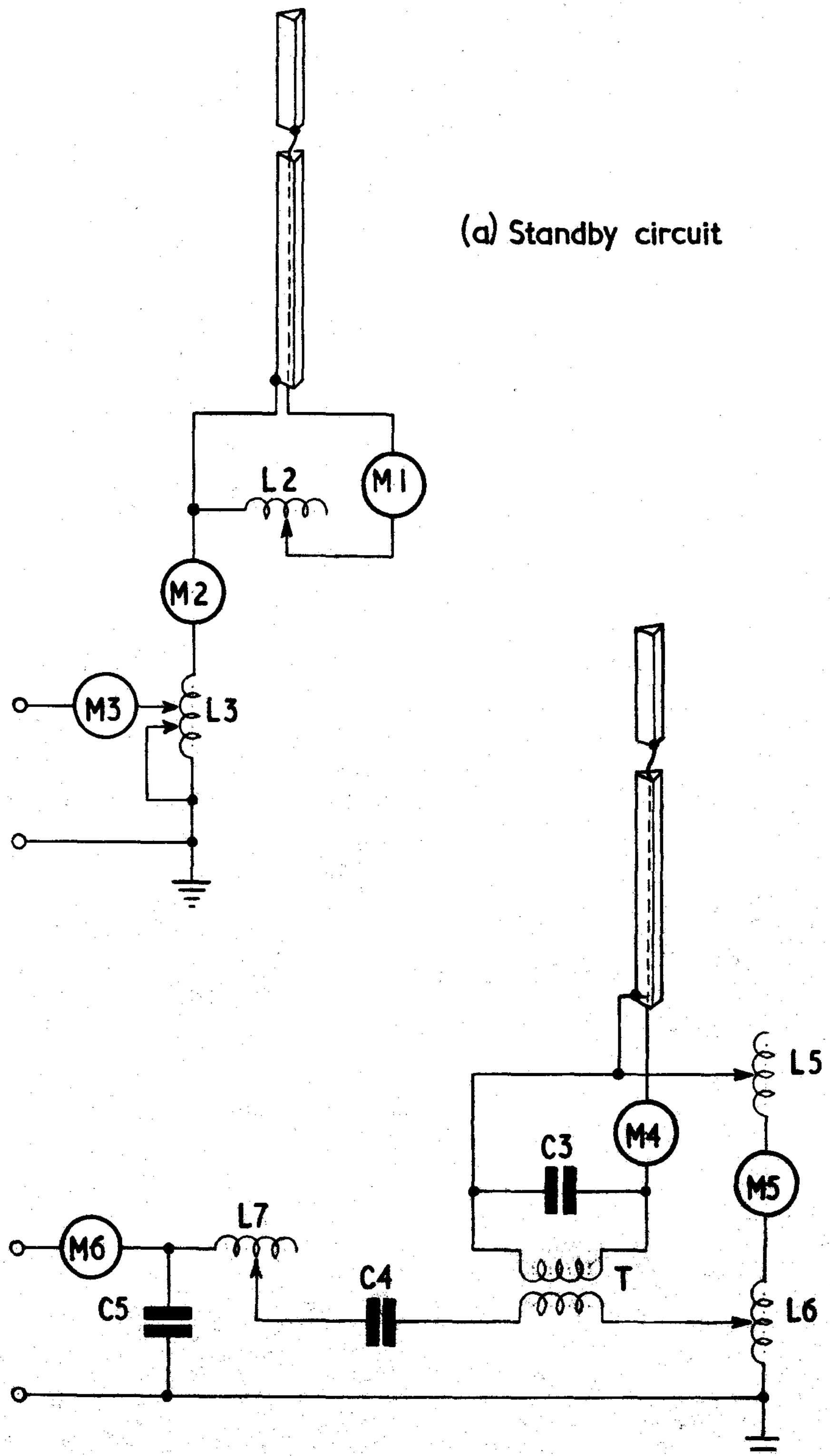

(a) Standby circuit

(b) Main circuit

Fig. 2.

ATH circuits

In addition to the existing lead-in from the base of the aerial to the A.T.H., a second lead-in was run from the inner conductor of the mast transmission line. Two change-over switches allow these leads to be connected either to the main circuit or to the simpler standby circuit.

The standby circuit, shown in Fig.2(a), feeds power directly to the base of the mast, as in the previous installation. But the loading reactance required at the break in the mast is now obtained by adjustment of L2, connected across the lower end of the mast feeder. The effective break reactance is then that presented by L2 at the top of the feeder, in parallel with the inductance of the lighting choke. L3 serves to match the load to the 300 Ω feeder, from the transmitter.

The main circuit is shown in Fig.2(b). If the tapping point on L6 is at the earthed end, all the power is fed to the mast-break via the transformer T and the mast transmission line. L5 and L6 then act solely as a base loading coil. Raising of the tapping point allows a certain amount of power to be taken from the base of the mast. C4, L7 and C5 are used for matching the load to the incoming 300 Ω feeder. The adjustment of L5, L6 and C3 for a suitable current distribution on the mast is described in Section 5, and the component values are given in Appendix A. Section 6 and Appendix B give corresponding details for the standby circuit.

3. Experimental methods

During adjustment of the circuits, it was required to measure the current on the mast at various heights above ground; this was done at low power, using a 5 watt oscillator to drive the mast at the carrier frequency (908 kc/s). A balanced screened loop could be clipped to the mast so that it projected outwards at a fixed distance from one of the vertical legs. It was broadly tuned to the required frequency, and incorporated a germanium crystal detector; by means of a portable microammeter and a flexible connector, an observer could take readings while on the ladder inside the mast.

In order to adjust the circuits, measurements were needed only in the region of the current minimum, but, after adjustment, the current distribution up to the mast break was measured for both main and standby circuits; the results are given in Fig.3.

The screened loop was also employed to investigate currents induced on other masts on the site when 908 kc/s was being radiated at high power. Some of this work was done during normal programme transmissions; a rejector circuit for 1214 kc/s was therefore incorporated in the loop so that readings would be unaffected by simultaneous transmission of the Light Programme.

The voltages given in the Appendices were deduced from low-power measurements, using a battery-operated diode voltmeter. The low-power oscillator was applied to terminals of known impedance so that the exact power could be deduced from the voltage measured across them. The voltages measured at various other points were then scaled up to a power of 140 kW.

4. Required current distribution

The mode of excitation of the aerial is determined by two independent real parameters, since it is controlled by the complex ratio of the voltages applied to the base and to the inner conductor. It is convenient to choose as parameters the height above ground of the current minimum, and the ratio of the minimum to the maximum current. By analogy with transmission line measurements, we may call the second parameter the standing wave ratio (s.w.r.).

Over flat ground of good conductivity, a s.w.r. equal to zero will give a vertical radiation pattern with a small minimum. The actual value of minimum radiation under this condition depends on the point on the mast at which power is being supplied, as well as on the ground constants. Thus on a site of relative permittivity 20-j180 (corresponding to a conductivity of $0.91 . 10^{-2}$ mho/m at 908 kc/s), the minimum value of radiation is expected to be somewhat less for the present mast (which has a break above the current loop) than for a similar mast fed at the current loop; the theoretical values are 0.016 and 0.033 respectively, expressed as a fraction of the maximum radiation. The use of a high feed point has the effect of compensating part of the effect of limited ground conductivity. The figures given assume that the s.w.r. is zero in both cases, and that we are concerned with a minimum in a direction approximately 30° from the vertical. A s.w.r. appreciably different from zero will, of course, give a much larger value of minimum radiation. In fact, for practical purposes we may say that the s.w.r. determines the sharpness of the minimum of the radiation pattern, while the angle θ_0 to the vertical at which it occurs is controlled by the height of the current minimum on the mast.

It was decided to adjust the aerial for a current distribution which would give a minimum of radiation at 30° to the vertical over perfectly conducting ground. The finite conductivity of the ground at Brookmans Park (about $0.8.10^{-2}$ mho/m) would be expected to increase this angle to 32°. For smooth ionospheric reflection at a height of 110 km, the corresponding minimum in the amount of sky wave occurs at about 136 km (85 miles) from the transmitter. Further details of the radiation pattern are given later.

The current distribution on the mast giving the required radiation pattern has a minimum 65 ft. above ground; both the main and the standby circuits were adjusted for a minimum at this height. The A.T.H. components have, however, been made capable of adjustment to give other distributions corresponding to values of θ_o in the range 27° - 39° should a different value be considered advantageous in the light of further experience.

5. Adjustment of main circuit

The complete circuit diagram is shown in Fig.2(b) (facing page 2) and the component values and ratings are listed in Appendix A. During the initial stages of adjustment, the components C5, L7 and C4 were disconnected, since they are concerned only with matching.

The tap on L6 was removed and the oscillator was applied to the primary of the transformer T, in order to feed the aerial entirely at the break via the mast transmission line. The current distribution near the base of the aerial was investigated and L5 was adjusted until the minimum was near to the required height of 65 ft. The minimum was blurred to some extent, but whereas the mast gave a s.w.r. of 0.29 when base fed (see Fig.3, standby circuit), the residual minimum current when fed at the break corresponded to a s.w.r. of just under 0.1.

We may compare these results with those expected by theory. As an approximation, we may regard the radiation resistance due to the current above 65 ft. as a lumped resistance of 69.2 Ω at the current maximum; the radiation resistance of the remaining portion below 65 ft., where the current is predominantly in antiphase, is then minus 3.7 Ω when referred to the loop current. When the mast is base fed, power is flowing upwards at the level of 65 ft. as in a transmission line of characteristic impedance 250 Ω terminated by 69.2 Ω, and a s.w.r. of 0.28 is expected.

If, instead, the aerial is fed entirely at the break, no power being allowed to enter or leave at the base (purely reactive base termination) there will still be some power flowing upwards past the level of the current minimum. This corresponds to power which is absorbed in the part of the mast below the minimum. Now the r.f. potential on the mast is a maximum at the minimum of current, and is much the same for a given total power whatever the method of feeding. Therefore the value of the current at the minimum will be proportional to the power it has to convey between the two parts of the aerial. It follows that the minimum current should be less than that for base-feeding by the factor 3.7/69.2 = 0.053, derived from the radiation resistances. As a result, a s.w.r. of 0.015 is expected, but the experimental value for centre-feeding appears to be considerably higher than this.

The discrepancy is believed to arise principally because the unbalanced feeder in the mast is not continued into the A.T.H., a separate unscreened lead-in being used to connect the inner of the feeder. When the circuit is apparently set for pure centre-feeding, some power is in fact fed to the base through stray impedances. A similar effect of approximately the same magnitude was observed in the case of the Third-Programme mast-radiator at Daventry. In both cases the unwanted coupling to the base was neutralised by raising the tap on L6 to a higher position than would otherwise have been necessary.

It will be seen from Fig.2(b) that the current distribution is determined by three components, C3, L5 and the tap on L6. (The transformer T contains no provision for adjustment). Now, since the current distribution can be described in terms of two real parameters, it can clearly be achieved in more than one way; in order to make a choice, some consideration other than the current distribution must be taken into account. At Daventry, this consideration was simplicity of adjustment, the method being as follows. C3 was adjusted so that the current minimum was at the required height when the aerial was base-fed, the primary of T being open-circuited. Then L5 was adjusted so that the current minimum was at the same height when the aerial was fed at the break only through T, the tap on L6 being moved down to earth. Ideally, it should then have been possible to make the s.w.r. zero by adjusting the tap on L6 only, the height of the minimum being unaffected. In fact the height changed slightly when the tap was moved, but a very small readjustment of L5 was sufficient to complete the adjustment.

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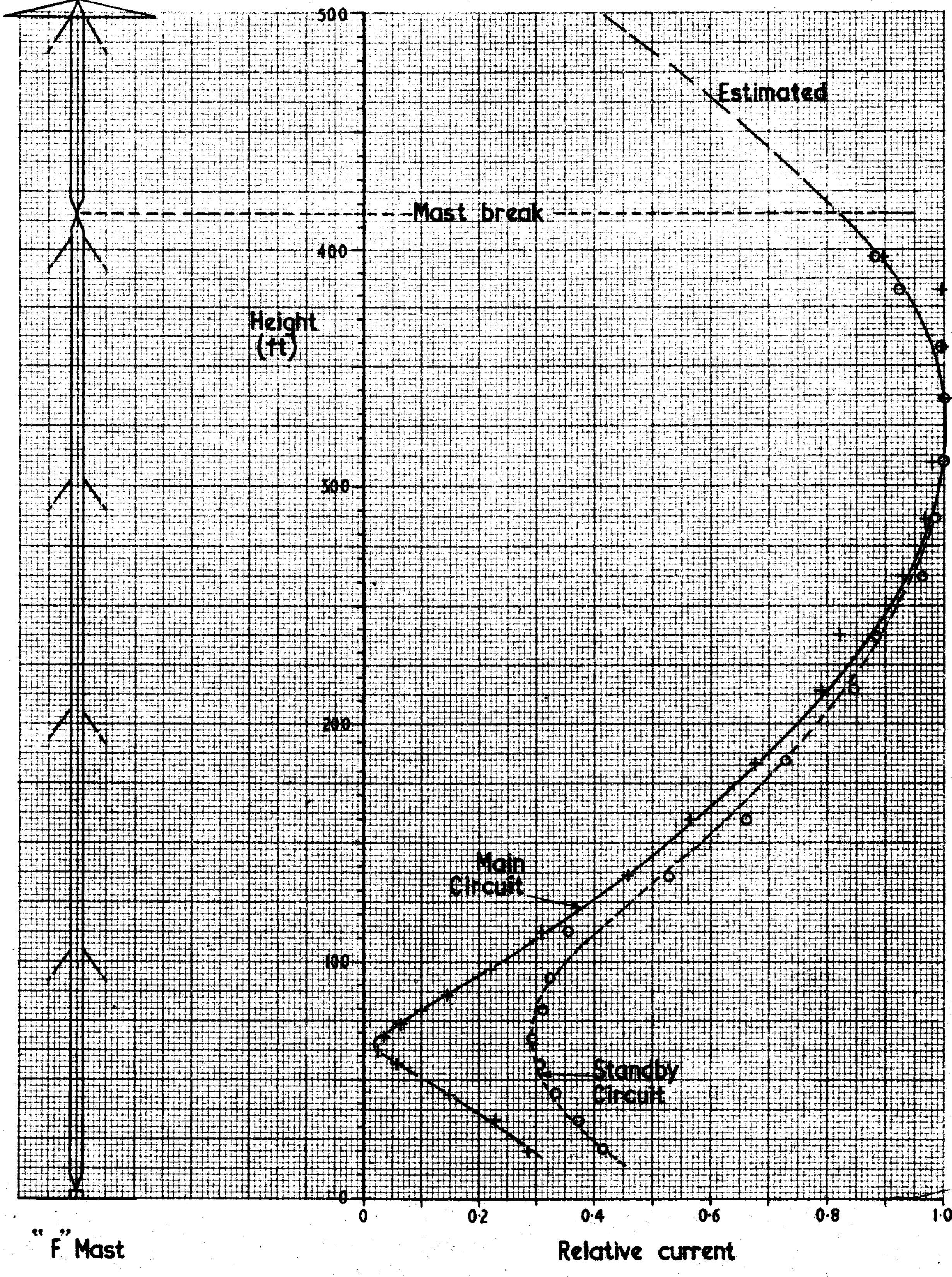

Fig. 3

Measured current distributions

At Daventry, the method of adjustment outlined above, in addition to being the simplest, also tended to minimise the reactive kVA in the circuit. This was unfortunately not the case at Brookmans Park, owing to the shortness of the upper section of the mast. The value of C3 arrived at by the above method was only 1000 pF, whereas 2700 pF would be required to tune the transformer. With the secondary so far off-tune the primary current would have been very large. C3 was therefore increased to 2400 pF, and the required current distribution was restored by raising the tapping on L6 and reducing L5.

A greater value of C3 would have required an unduly high tapping on L6. Measurements of input impedance showed that increasing C3 above 1000 pF was well worth while, since the estimated transformer primary current needed to supply 140 kW was reduced from about 106 amp to 74 amp.

The current distribution finally achieved is shown in Fig.3. It is seen that the s.w.r. is 0.02.

The basic matching circuit consists of two condensers, C4 and C5, but L7 provides a convenient fine adjustment of the series reactance. As it happened, a good match was obtained using available components with L7 short-circuited; this setting was preferred, since the voltage across C4 and the power loss in the matching circuit were then no greater than was necessary. The input impedance finally obtained corresponded to a s.w.r. on the main feeder (taken as 295 Ω characteristic impedance) of 0.94 at 908 kc/s, dropping to 0.86 at 10 kc/s either side of the carrier frequency.

6. Adjustment of standby circuit

The standby circuit shown in Fig.2(a) (facing page 2) was provided for use in case of failure of any components in the relatively complex main circuit. The component values and ratings are given in Appendix B. With the low-power oscillator applied to the mast base, the coil L2 was adjusted to give a current minimum on the mast at a height of 65 ft making the distribution similar, apart from the feed current, to that for the main circuit. This is shown by the results given in Fig.3. The matching to the impedance of the main feeder was then carried out, using the two tapping adjustments on L3.

7. Reduction of re-radiation from other masts

To take full advantage of the reduction in high-angle radiation when using the new main circuit, the effect of re-radiation from other masts and aerials on the site had to be considered. A plan of the site is given in Fig.4 and the details are summarised in Table 1. The masts on the far side of the transmitter building from the Home-Service aerial (F), namely two 200 ft. self-supporting towers, C and D, and a stayed 250 ft. mast, E, did not require adjustment. They were already provided with rejector circuits, which open-circuited the base at 908 kc/s. Under this condition, calculation shows that, at 30° to the vertical, re-radiation from any mast is about 1% or less of the direct horizontal radiation. Their function as parasitic elements to obtain horizontal directivity on 1214 kc/s remains unaffected.

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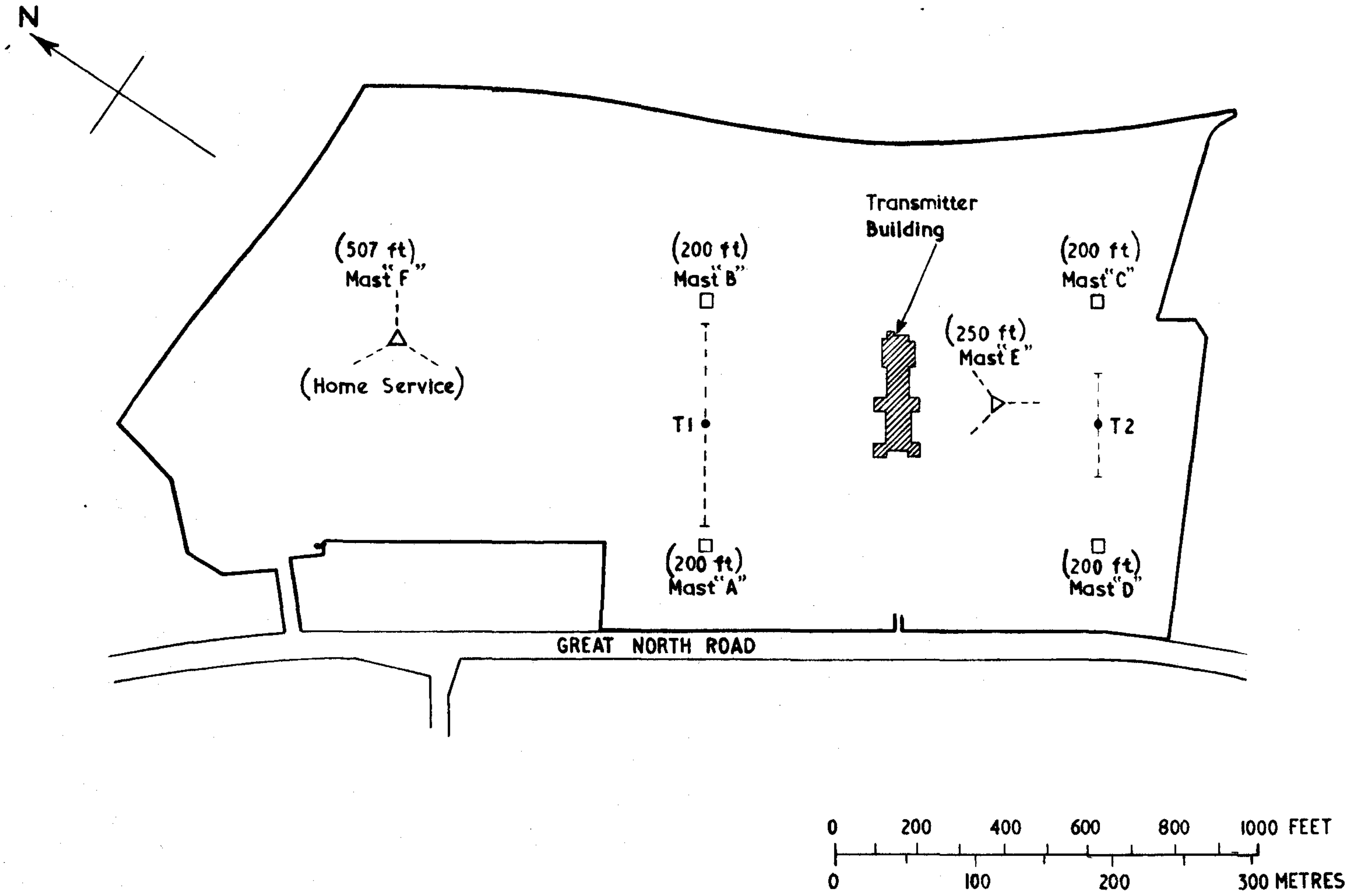

Fig. 4

Site plan of Brookmans Park station

TABLE I

Aerial	Type	Height at centre (ft.)	Top length (ft.)	Base termination at 908 kc/s (ohms)	Theoretical estimate of re-radiation (% of direct horizontal radiation)	
				(r.c. = rejector circuit)	Horizontal	30° to vertical
A	self-supporting towers	200	-	j30(5.3 μH)	< 0.5	< 0.3
B		200	-	j30(5.3 μH)	< 0.5	< 0.3
C		200	-	∞(r.c)	2.7	1.2
D		200	-	∞(r.c)	2.6	1.2
E	stayed mast	250	-	∞(r.c)	0.73	0.31
T1	T-aerials	160	2 x 250	j500(90 μH)	0.68	0.33
T2		160	2 x 130	∞(r.c)	0.68	0.29

A rejector circuit was fitted to the 1214 kc/s T-aerial, supported between masts C and D, in order to open-circuit it at 908 kc/s.

The two other 200 ft. towers, A and B, and the reserve T-aerial between them, required more careful consideration, since they were only about three-quarters of a wavelength from the radiating mast. In order to minimise re-radiation from the towers, both in horizontal directions and at high angles, an inductive load was connected between the base and earth. The required base inductance was determined experimentally on Mast A, the small screened loop being used to investigate the current in one of the four limbs of the mast while a high power transmission was made from the mast-radiator. Adjustment was made so that a minimum in the induced-current distribution occurred about 50 ft. from the ground, thus making the current-moment of the whole aerial very small.

It was found, incidentally, that different limbs of the tower indicated different values of induced current, showing the presence of circulating currents. The effective current was therefore deduced from the average of two readings taken on the diagonally opposite limbs that were almost equidistant from the mast-radiator. An approximate calibration of the current-measuring meter was made by comparison with an ammeter connecting one leg of the mast to earth, the other three legs being earthed directly. The total induced mast current at heights of 30 ft. and 80 ft. was then deduced from loop-meter readings, both for an open circuit termination and for the optimum termination at the base. The results were in fair agreement with a theoretical estimate, which took into account the non-uniform cross-section. The actual value of inductance required for the coil at the base of the mast was, however, much lower than the theoretical estimate. This was, no doubt, due to the effects of a large base capacity and to stray inductances, which had not been taken into account.

The reserve T-aerial between masts A and B has a long top, so that the moment of the induced current would be large if the aerial were kept open-circuited at the base. A suitable impedance (an inductance) for keeping the re-radiation to a minimum was therefore connected between the base and earth. In this case, the theoretical value was considered sufficiently accurate, since experiments with power on the mast radiator had shown that the induced base currents, for various inductive terminations of the T-aerial, were in good agreement with theory.

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APP D

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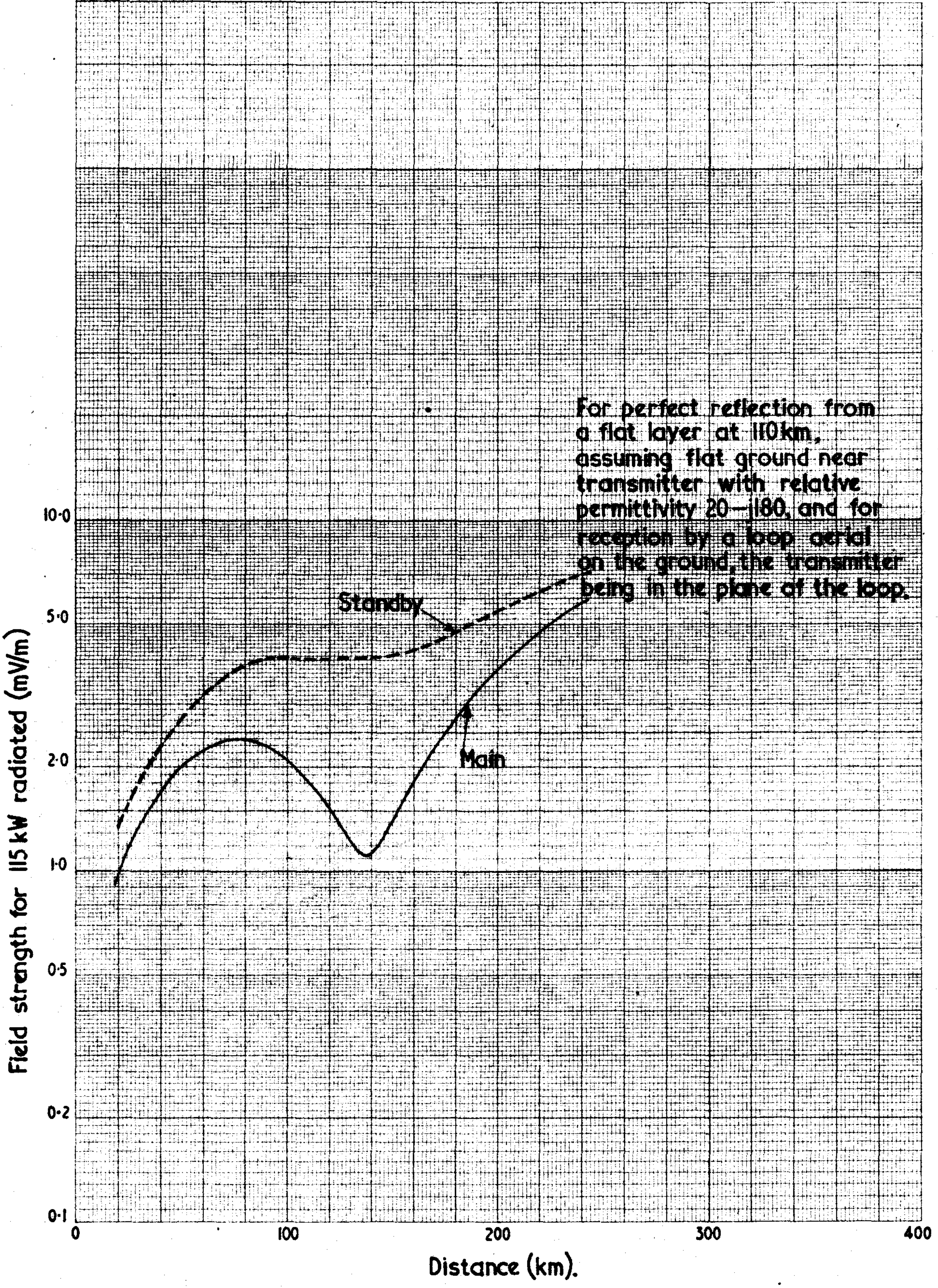

For perfect reflection from a flat layer at 110 km, assuming flat ground near transmitter with relative permittivity 20−j180, and for reception by a loop aerial on the ground, the transmitter being in the plane of the loop.

Fig. 5

Idealized curves of sky-wave strength for Brookmans Park (908 kc/s).

8. Performance

The idealized performance is illustrated in Fig.5. This gives the field strength due to the sky wave at various distances, assuming for simplicity a uniform metallic reflector at a height of 110 km. The ground surrounding the transmitting aerial has been assumed perfectly flat and uniform, and its finite conductivity has been taken into account. It has been assumed, in the case of the main circuit, that the aerial is fed at the current loop and that the mast current has a zero s.w.r. The theoretical curve for the actual mast should have a sharper minimum, since the minimum field strength is approximately halved through the use of a high feed point. The curve given for the standby circuit (mast base-fed) is applicable also to the normal method of operation before modification of the aerial.

Since the new installation came into service in September, 1952, some records of fading have been made at distances of 100 to 160 km from Brookmans Park. Unfortunately, the effect of combined feeding on the amount of fading cannot be given in a direct manner, because a comparable set of fading records is not at present available for the mast in the base-fed condition at 908 kc/s. Nevertheless, if the peak values of sky-wave field strength are deduced from the records, and plotted against distance from the transmitter, there is some indication of a minimum at a range of 135 km, as expected. Absolute peak values of sky wave were close to or slightly below the curve of Fig.5, while values exceeded for 5% of the total time were generally about half the peak value. These results are based on records taken for one or two nights at each locality, periods of an hour or more, when the sky wave was relatively strong, being selected for analysis. It is known from experience with the Daventry mast that the theoretical curve may not be closely followed, because site irregularities can affect the radiation pattern, and because irregularity of the ionosphere may further disturb the effective radiation pattern after reflection. Further measurements are required before these effects can be gauged quantitatively.

Some improvement was noticeable in the uniformity of the horizontal radiation patterns at 5 km range. This was presumably due to the reduction in re-radiation from the other masts and aerials on the site.

A survey of the ground wave strength over the service area has shown values much the same as before in directions to the east and west of the transmitter, but values towards the north appeared to have increased slightly, and those to the south to have decreased slightly. These changes (of the order of 10%) seem to be slightly greater than any change observed in the horizontal radiation pattern at a distance of 5 km.

It was not possible to estimate the efficiency of the aerial system very accurately. Measurements of field strength at a range of 5 km from the transmitter gave a mean value of 822 mV/m. Radio frequency ammeters, installed at each end of the feeder from the transmitter to the A.T.H., indicated a transmitter power of 125 kW and a power into the A.T.H. of 118 kW during the field-strength measurements. The difference is consistent with the theoretical loss in the 1000' length of partially-screened transmission line. The theoretical value of $(E\ d)_o$ (limiting value of field strength times distance at very short range) is 400 volts for 1 kW radiated. These figures lead to an apparent radiated-power efficiency of 113% referred to the power into the A.T.H. A reasonable ground-wave attenuation factor (0.89) has been allowed, but no account has been taken of height-gain[7]; if anything, the latter effect would increase the discrepancy between theory and experiment still further.

The cause of the discrepancy is not known at present; the ammeter readings and the field-strength measurements could well be a few percent in error, although it was found that the power indicated by a peak voltmeter and by more than one ammeter in the A.T.H. agreed closely.

9. Conclusion

By modifications to the mast-radiator and A.T.H. circuit, the current distribution has been changed so that it has a nearly perfect zero at a height of 65 ft. from the ground. This should bring about a reduction in the severity of the fading experienced at the outer edge of the service area. There is, however, no consequent increase in the ground-wave field strength, so that, where the service area is limited by interfering signals, no improvement can be expected. Thus it was found that, particularly south of London, the effect of the new method of feeding on the service area could not be appraised by listening tests, owing to the severe interference from the continent - principally from Dresden on approximately 911 kc/s. A few records of fading have, however, suggested that a reduction in the sky wave has been achieved, particularly at ranges between 130 and 135 km. Sufficient information is not yet available to assess the importance of site irregularity on the vertical radiation pattern. The performance of the Daventry radiator is known to be severely affected on certain bearings, but since the site at Brookmans Park is flatter than that at Daventry, the performance is expected to be somewhat better. It is hoped to carry out radiation pattern measurements by the reflected pulse method at a later date.

10. References

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2. "Interim Report on Brookmans Park 342 m Mast Radiator", Research Department Report No.E031, Serial No.1947/34, January, 1948.

3. "The Measured Radiation Patterns of Vertical Aerials over a Perfectly Conducting Earth", Research Department Report No.E036, Serial No.1950/1, May, 1950.

4. "The Measured Radiation Patterns of Vertical Aerials over an Imperfectly Conducting Earth", Research Department Report No.E041, Serial No.1951/16, November, 1951.

5. "The Measured Radiation Patterns of Vertical Aerials over a Poorly-Conducting Earth, and upon Hills", Research Department Report No.E043, Serial No.1952/17, July, 1952.

6. "Interim Report on Daventry Third-Programme Mast-Radiator", Research Department Report No.E040, Serial No.1951/12, October, 1951.

7. "The Height-Gain Factor for a Vertical Medium-Wave Aerial", Research Department Report No.E045, Serial No.1953/8, May, 1953.

11. Appendix A: Main Circuit

(m) = maximum value or rating

(o) = operation value for 140 kW r.m.s. unmodulated carrier

Notes

(1) Although operating values are given for the nominal power of 140 kW the actual power is at present 120 - 125 kW at the transmitter and about 115 kW at the A.T.H.

(2) The component numbers are as shown in Fig.2 and correspond to those used on BBC Planning and Installation Department drawings.

(3) Voltages are derived from low-power measurements unless otherwise stated. Currents are either based on high power meter readings or deduced from impedance measurements.

Components

T No adjustment is provided

Primary inductance: 16.8 µH

Secondary inductance: 11.3 µH

Mutual inductance: 7.0 µH (coupling coefficient 0.5)

Primary current: (m) 90A (o) 74A

Secondary current: (m) 110A (o) 57A

Max. P.D. primary to earth: (m) 14.5 kV (o) 10.2 kV (from impedance)

Max. P.D. secondary to earth: (m) 21 kV (o) 10.7 kV

Max. P.D. between windings: (m) 25 kV (o) 6.9 kV

L5 Inductance: (m) 50 µH (o) 6.0 µH (1 3/4 turns; spare turns each end open-circuited)

Current: (m) 90A(o) 61A

L6 Inductance: 8.9 µH (tap set 1½ turns above earth)

Current: (m) 150A (o) not measured, but not exceeding 135A

Note: Stray lead-inductance between L5 and L6 above was 5.1 μH; the total base-loading inductance must be of the order of 30 μH but this is shunted by a total base capacity of about 700 pF, taking into account both the mast and A.T.H. circuit.

L7 Inductance: (m) 50 μH (o) zero (short-circuited)

Current: (m) 90A

C3 Capacitance: (m) 3500 pF (o) 2400 pF

Voltage: (m) 7.5 (o) 5.0 kV

C4 Capacitance: (m) 3000 pF (o) 2200 pF

Voltage: (m) 7.5 kV (o) 5.3 kV

C5 Capacitance: (m) 3000 pF (o) 1700 pF

Voltage: (m) 7.5 kV (o) 6.4 kV

Meter Currents (Values in brackets correspond to present aerial power of 115 kW)

M4 (m) 85A (o) 38A (35A)

M5 (m) 100A (o) 61A (56A)

M6 (m) 30A (o) 21.5A (19.5A)

Insulator Voltages

Mast base: (m) 14.1 kV (o) 10.6 kV) estimated
Mast break: (m) 9.1 kV*(o) 4.2 kV) theoretically

Lead-in from inner of mast transmission line (o) 10.7 kV)measured
)inside
Lead-in from mast base (o) 9.2 kV)A.T.H.

Voltage across mast transmission line at base of mast (m) 9.1 kV (o) 3.7 kV

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* limited by rating of transmission line

12. Appendix B: Standby Circuit

(See notes at beginning of Appendix A)

Components

L2 Inductance: (m) two 80 μH coils in series (o) one coil;
4.3 μH (2 turns, spare turns each end short-circuited)

Current: (m) 45A (o) 33A

L3 Inductance: (m) 100 μH (o) 5 1/4 turns with 6 turns short-circuited at earthed end, and 2 3/4 turns open-circuited at other end; tap 3 3/4 turns above earth.

Current: (m) 90A (o) 65A

Meter Currents (Values in brackets correspond to present aerial power of 115 kW)

M1 (m) 50A (o) 31A (28A)

M2 (m) 100A (o) 65A (59A)

M3 (m) 30A (o) 21.2A (19.3A)

Insulator Voltages

Mast base (m) 14.1 kV (o) 11.1 kV)
Mast break (m) 9.1 kV (o) 0.2 kV) estimated theoretically

Lead-in from inner of mast transmission line (o) 11.0 kV)
Lead-in from mast base (o) 9.6 kV) measured inside A.T.H.

Voltage across mast transmission line at base of mast (m) 9.1 kV (o) 2.0 kV